Radiation Report on **OP27A (LDC 9347 and 9407)**
Project: SET

A radiation evaluation was performed on **OP27A operational amplifier (Analog Devices)** to determine the total dose tolerance of these parts. The total dose testing was performed using a Co^{60} gamma ray source. During the radiation testing, five parts were irradiated under bias and one part was used as a control sample. The total dose radiation levels were 20, 30, 40, 50, 60, 80, 90, and 100kRads(Si). The average dose rate was 0.602krads(Si)/hour (0.17rads(Si)/s). After the 100krad(Si) irradiation, the parts were annealed under bias at 25°C for 168 hours. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits listed in Table III. An executive summary of the test results is provided below in bold, followed by a detailed summary of the test results after each radiation level and annealing step.

All parts passed all tests up to 20krads(Si). Some degradation was seen in a few parts in +Ib, -Ib and Ios from 30 to 40krads(Si). Significant parametric degradation was seen in all parts in those three parameters from 50 to 100krads(Si). It is worthy of note that the devices never failed functionally. After annealing the parts at 25°C for 168 hours, significant recovery was noted in the sensitive parameters with two parts passing both Ib tests. There appears to be slightly better performance in the devices from LDC 9407.

Initial electrical measurements were made on 6 samples. Five samples (SN's 1332, 1444, 219, 220, and 341) were used as radiation samples while a spare device was used as a control sample. All parts passed all tests during initial electrical measurements. SN's 1332 and 1444 had the following external markings: top: 9347 JM38510/13503SGA, around rim: (SN) PMIAW17F S104 347 CEGA USA. SN's 219, 220 and 341 were marked: top: 9407 JM38510/13503SGA, around rim: (SN) PMIAW17F S369 407 CEGA USA.

During the first attempt at the 60krad(Si) run, the plug was kicked out for the power supplies and the devices were not biased for that irradiation. The parts were tested again following the unbiased irradiation and continued the test.

All parts passed all tests up to 20.0krads(Si).

After the 30krad(Si) run, SN 341 exceeded the specification limit of 35nA for Ios with a reading of 71nA.

After the 40krad(Si) run, SNs 1144, 341, and 1332 exceeded the specification limit of 40nA for +Ib and -Ib with readings in the range of 41 to 70nA. SNs 1144, 341, and 1332 exceeded the specification limit of 35nA for Ios with readings in the range of 45 to 135nA.

After the 50krad(Si) run, all devices exceeded the specification limit for +Ib and -Ib with readings in the range of 49 to 155nA. All devices exceeded the specification limit for Ios with readings in the range of 67 to 94nA.

After the 60krad(Si) run, all devices exceeded the specification limit for +Ib and -Ib with readings in the range of 40 to 193nA. All devices exceeded the specification limit for Ios with readings in the range of 38 to 199nA.

After the 80krad(Si) run, all devices exceeded the specification limit for +Ib and -Ib with readings in the range of 147 to 307nA. All devices exceeded the specification limit for Ios with readings in the range of 151 to 309nA.

After the 90krad(Si) run, all devices exceeded the specification limit for +Ib and -Ib with readings in the range of 146 to 260nA. All devices exceeded the specification limit for Ios with readings in the range of 147 to 250nA.

After the 100krad(Si) run, all devices exceeded the specification limit for +Ib and -Ib with readings in the range of 190 to 316nA. All devices exceeded the specification limit for Ios with readings in the range of 194 to 317nA.

After annealing the parts for 168 hours at 25°C, significant recovery was noted in the Ib measurements with two devices giving readings within specification limits and SNs 1444, 220 and 219 had readings in the range of 86 to 133nA. All devices were still exceeding the specification limit for Ios, but with readings in the range of 88 to 130nA.

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

TABLE I. Part Information

Generic Part Number:	OP27A
SET Plastic Part Number	JM3815/13503SGA
SET TID Requirement	Up to 100krads(Si)
Manufacturer:	Analog Devices (PMI)
Lot Date Code (LDC):	9347 and 9407
Quantity Tested:	5
Serial Numbers of Control Samples:	No number (one device)
Serial Numbers of Radiation Samples:	1332, 1444, 219, 220, 341
Part Function:	Operational Amplifier
Part Technology:	Bipolar
Package Style:	TO can
Test Equipment:	Custom setup
Test Engineer:	C. Palor

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for OP27A

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	09/22/04
2) 20 KRAD IRRADIATION (0.9 KRADS (Si)/HOUR)	09/23/04
POST-20 KRAD ELECTRICAL MEASUREMENT	09/24/04
3) 30 KRAD IRRADIATION (0.14 KRADS (Si)/HOUR)	09/24/04
POST-30 KRAD ELECTRICAL MEASUREMENT	09/27/04
4) 40 KRAD IRRADIATION (0.5 KRADS (Si)/HOUR)	09/27/04
POST-40 KRAD ELECTRICAL MEASUREMENT	09/28/04
5) 50 KRAD IRRADIATION (6.7 KRADS (Si)/HOUR)	09/28/04
POST-50 KRAD ELECTRICAL MEASUREMENT	09/28/04
6) Unbiased 10 KRAD IRRADIATION (6.7 KRADS (Si)/HOUR)	09/28/04
POST-Unbiased 10 KRAD ELECTRICAL MEASUREMENT	09/28/04
7) 60 KRAD IRRADIATION (0.6 KRADS (Si)/HOUR)	09/28/04
POST-60 KRAD ELECTRICAL MEASUREMENT	09/29/04
8) 80 KRAD IRRADIATION (7.6 KRADS (Si)/HOUR)	09/29/04
POST-70 KRAD ELECTRICAL MEASUREMENT	09/29/04
9) 90 KRAD IRRADIATION (0.5 KRADS (Si)/HOUR)	09/29/04
POST-90 KRAD ELECTRICAL MEASUREMENT	09/30/04
10) 100 KRAD IRRADIATION (8.6 KRADS (Si)/HOUR)	09/30/04
POST-100 KRAD ELECTRICAL MEASUREMENT	09/30/04
11) 168 HOUR ANNEALING @25°C	09/30/04
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/07/04

Average Dose Rate = 100,000RADS(Si)/166 HOURS=602RADS(Si)/HOUR=0.17RADS(Si)/SEC

Table III. Electrical Characteristics OP27A

Test #	Parameter	Units	Spec. Limit min	Spec. Limit max	Notes
1	+Ib	nA		±40	
2	-Ib	nA		±40	
3	Ios	nA		35	
4	Vos	µV		25	
5	Vo+	V	12		
6	Vo-	V		-12	
7	Pd	mW		140	

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP27A (1)

					Total Dose Exposure (kRads Si)																		Annealing	
					Initial		20		30		40		50		60		60+10 unbiased (3)		80		90		100		168 hours @25°C	
Test #	Parameters	Units	Spec. Lim. (2) min	Spec. Lim. (2) max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	+Ib	nA		±40	4.0	2.8	8.3	2.3	19.7	11.6	44.0	21.6	99.0	44.1	104.0	66.6	175.6	51.0	226.2	66.2	203.4	44.7	257.2	50.0	66.6	51.4
2	-Ib	nA		±40	4.6	3.0	8.5	2.8	19.9	11.7	43.5	22.0	98.8	45.0	110.0	69.3	172.4	49.2	228.6	65.2	203.6	43.8	260.4	49.1	68.6	54.0
3	Ios	nA		35	4.8	2.8	10.4	12.0	28.0	25.8	59.3	46.2	75.9	22.0	116.6	73.3	175.0	47.5	228.8	64.4	204.2	42.6	260.0	49.9	112.6	17.8
4	Vos	µV		25	-105.2	48.5	-88.6	47.4	-91.2	11.7	-81.4	24.0	-104.3	17.6	-88.4	11.9	-111.0	15.1	-99.2	12.2	-101.6	7.7	-84.4	13.5	-84.4	16.5
5	Vo+	V	12		14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0	14.5	0.0
6	Vo-	V		-12	-14.2	0.0	-14.2	0.0	-14.2	0.0	-14.2	0.0	-14.3	0.1	-14.3	0.0	-14.3	0.0	-14.3	0.0	-14.3	0.0	-14.3	0.0	-14.3	0.0
7	Pd	mW		140	48.8	0.8	44.6	1.7	43.4	1.3	41.8	1.8	39.8	1.8	36.0	2.3	38.6	1.5	36.4	1.8	37.8	1.3	36.6	1.5	40.6	1.1

Notes:

(1) The mean and standard deviation values were calculated over the five parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this table.

(2) No specification limits were given at the time of testing. Parameters selected by the project and tested according to the needs of the flight configuration.

(3) The devices were accidently unbiased during this irradiation step. This 10krad(Si) dose does not add to the overall total biased dose.

Radiation sensitive parameters: +Ib, -Ib, Ios